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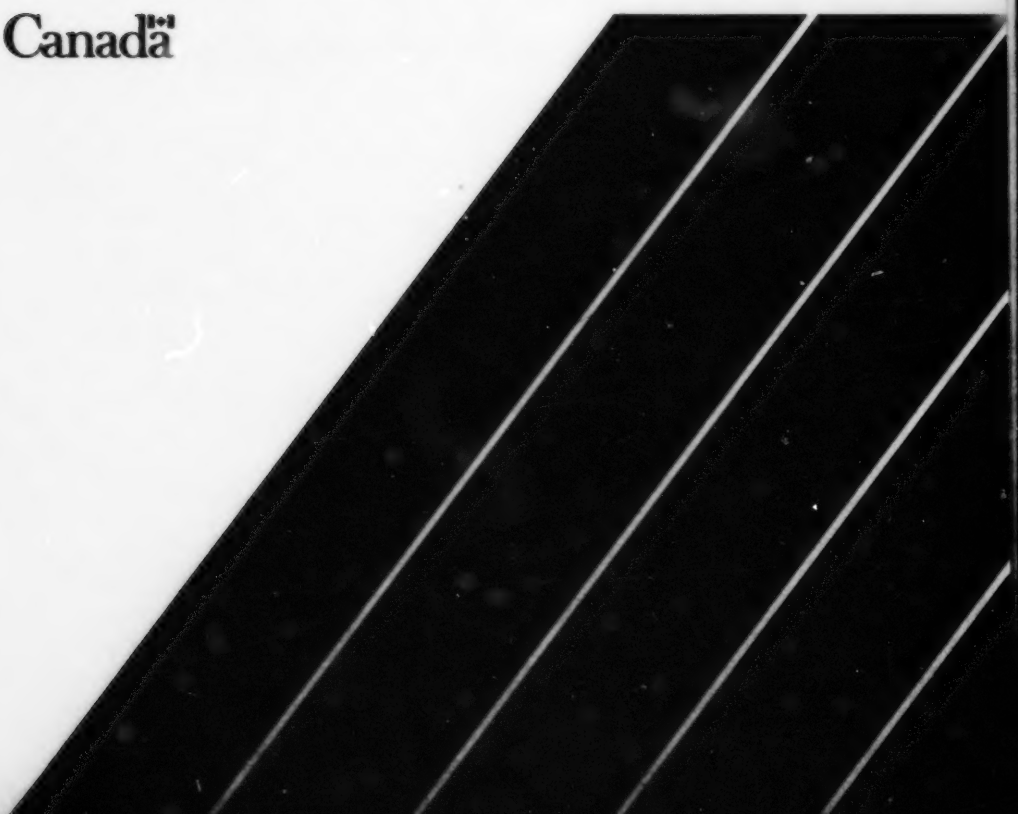
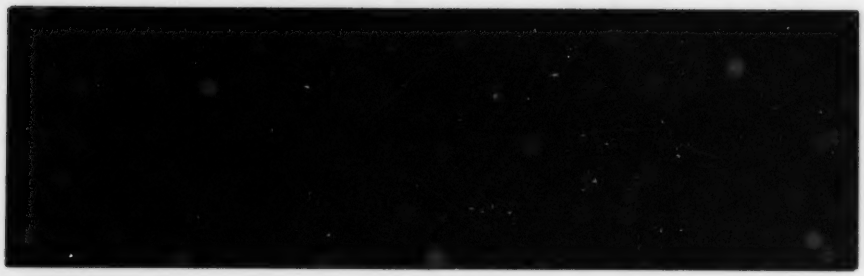
PURE SILICA STANDARD FILTER PREPARATION FOR THE CALIBRATION OF X-RAY DIFFRACTOMETERS

J.D. Stanway, M.G. Grenier and K.C. Butler

MRL 92-016 (TR) February 1992

Canada





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PURE SILICA STANDARD FILTER PREPARATION FOR THE CALIBRATION OF X-RAY DIFFRACTOMETERS

J.D. Stanway*, M.G. Grenier** and K.C. Butler+

ABSTRACT

A procedure has been adopted to produce a uniform deposit of a known mass of pure silica on 25 mm silver membrane filter discs of 5 μm pore size. These standard filters were produced using sampling trains of the same type as those used in mines. Sampling trains were located inside a dynamic dust tunnel containing pure silica dust. The filters obtained in this fashion can be used for the calibration of X-ray diffractometers which measure silica mass on sample filters from mines. The mass of silica on standard filters varied between 0.02 and 0.56 mg. The uncertainty associated with these masses was less than 0.02 mg.

Key words: Dust sampling; Silica analysis; Quartz standards.

*Student, University of Waterloo, Applied Physics Co-op., **Research Scientist, and +Technologist, Elliot Lake Laboratory, CANMET, Energy, Mines and Resources Canada, Elliot Lake, Ontario.

PRÉPARATION DE FILTRES STANDARD À SILICE PUR POUR L'ÉTALONNAGE DE DIFFRACTOMÈTRES À RAYONS X

J.D. Stanway*, M.G. Grenier** et K.C. Butler+

RÉSUMÉ

Les auteurs ont adopté un procédé en vue de produire un dépôt uniforme d'une masse connue de silice pur sur des disques de membranes filtrantes en argent de 25 mm qui ont des pores de 5 μ. Ils ont produit ces filtres standard en utilisant des chaînes de prélèvement du même type que celles qui se trouvent dans les mines. Les chaînes de prélèvement étaient situées à l'intérieur d'un tunnel à poussières dynamique qui contenait de la poussière de silice pur. Les filtres produits de cette façon peuvent servir à l'étalonnage de diffractomètres à rayons X qui mesurent les masses de silice sur les filtres échantillonneurs dans les mines. La masse de silice sur les filtres standard variait de 0,02 à 0,56 mg. L'incertitude associée à ces masses est inférieure à 0,02 mg.

Mots clés : prélèvement de poussière, analyse de silice, étalons de quartz

*Étudiant inscrit à un programme co-opératif en physique appliquée, Université de Waterloo, **chercheur et +technologue, Laboratoire de Elliot Lake, CANMET, Énergie, Mines et Ressources Canada, Elliot Lake (Ontario).

Contents

Abstract i
Introduction 1
Apparatus 1
Method 2
Results 4
Accuracy of the Method 4
Discussion 5
Conclusions 5
Acknowledgement 5
References 5
Appendix A - Temperature, Humidity and Dust Concentration Data A-9
Appendix B - Dust Particle Size Distribution B-19
Appendix C - Conditions and Settings for Individual Sampling Runs C-20
Appendix D - Cyclone Sampling Positions D-30

Tables

1. Mass calculated on selected filters using ten weighings 6
2. Mass calculated on selected filters using two weighings 6
3. Standard filters, associated mass of silica, and length of sampling interval 7

Introduction

This work was undertaken in late 1991, after discussions with the Ontario Ministry of Labour, Inco Ltd., Dofasco Inc., and X-Ray Assay Laboratories. From these contacts it appears that there was a need for pure silica standards ranging in mass between 0.02 and 0.50 mg, with the majority of the filters being below 0.10 mg to better define the low mass portion of the calibration curve used in the routine assessment of silica mass using X-ray diffractometry.

This report describes the equipment used to conduct this work in the Elliot Lake Laboratory's dynamic dust tunnel. The method is described in some detail for future reference for the Elliot Lake Laboratory technical staff. All data pertaining to the dust tunnel runs performed to obtain the 100 standard silica filters are shown along with a list of filter numbers and masses.

Apparatus

Pure silica was deposited on 25 mm silver membrane filter discs with 5 μm pore sizes. The filters were weighed using a Mettler AE136 dual range balance. The 0 to 30 g range was used at a readability of 0.01 mg. The filters were placed in Nucleopore three section cassettes, and each was attached to a cyclone pre-separator which removed the non-respirable portion of the airborne dust. The cyclone/cassette assemblies were used in conjunction with critical orifices and a vacuum pump to produce a stable flow rate of 1.7 L/min ($\pm$10 cc) as measured by an A.P. Buck Mini-Buck Flow Calibrator (model M-5).

A few preliminary tests and the actual standard runs were performed in a closed circuit dust/wind tunnel, manufactured by GasTOPS Ltd. The overall dimensions of the tunnel are 2 m x 9 m x 2.8 m (w x l x h). The cyclones were suspended from wires across the width of the largest of three chambers of the tunnel. This section is approximately 1.5 m long and 85 cm x 85 cm in cross-section. The 'core' of the flow in this chamber is considered to extend to within 1/8 the chamber width of the chamber wall, with the air velocity being uniform within 5% of the mean (1). Air velocity for these runs was approximately 0.6 m/s.

The velocity of air in the tunnel was controlled by a centrifugal fan powered by a 3 Hp, 220 V General Electric Induction Motor. Motor speed was controlled

by a Toshiba Transistorized Inverter. The inverter frequency was set at 15.0 Hz for these tests.

The pure silica dust used in these tests was Min-U-Sil 30 μm which was introduced into the tunnel by a Wright dust feeder. In this device, dust is placed on a grooved turn-table which is rotated by a 1/8 Hp Reducer Motor. Clean, dry, compressed air is injected into the tunnel which draws dust from the turn-table into the air stream. This dust passes through a TSI Aerosol Neutralizer (Model 3054) to reduce dust charge distribution to background levels.

The size distribution of the dust was measured by a Sierra Series 210 Ambient Cascade impactor. This device separates dust according to size on slotted glass fibre filters in nine stages. The particle cut-off size defined by the nine stages encompasses the entire respirable range. Air enters through four radial slots in the first stage and particles larger (by aerodynamic as opposed to geometric size) than the cut-off point of the first stage impact on the filter. Then the air stream flows through the narrower slots in the second stage, and smaller particles impact on the second filter, and so on. The size of the sections and of the radial slots decrease with each succeeding stage, thus increasing air velocity. At the last stage, the remaining particles are trapped by a glass fiber filter (2). An Anderson series 110 constant air flow sampler draws air through the impactor at a set flow rate of 13 L/min.

Meteorological conditions and air velocity were measured as a function of time in the tunnel. To measure air velocity, a Solomat MPM500e hotwire airspeed probe was used. Atmospheric pressure was measured with a Wallace and Tiernan Precision Aneroid Barometer (model FA1122170) located outside the tunnel.

Dust concentration was measured with a Mie Inc. MiniRam Personal Dust Monitor (model PDM-3). This device measures dust based on the detection of scattered electromagnetic radiation in the near infrared (3). The MiniRam located outside the dust tunnel was coupled to a DuPont Constant Flow Sampler (model P-2500), which pumped air from the dust tunnel through a flow-through chamber on the MiniRam. Data from the MiniRam were recorded by a Grant 1200 Series (12-Bit) Squirrel Meter/Logger (model 1201). The temperature and relative humidity were also recorded by the Squirrel logger which was attached to a combination humidity/temperature probe located in the tunnel.

Method

Initially, four test runs were performed in order to determine the amount of sampling time required to produce filters with adequate silica mass. The first three were performed with each cassette coupled to a Gilian Series 513 or Gil-Air pump, and the fourth was performed with sampling trains being run from critical orifices, as described in the previous section. Fourteen filters were used in the first three runs, and six were used in the fourth. All valves and pumps connected to the cassettes were left on for four hours. The mass of dust left on each filter was approximately 0.4 mg, leading to the conclusion that the rate of accumulation of dust on the filters was approximately 0.1 mg per hour.

Before a run of the dust tunnel, all silver membrane and cascade impactor filters were weighed. The filters were left to acclimatize in the weighing room for several days. The temperature and relative humidity were recorded both before and after weighing. Each filter was weighed twice and the average of the two values was recorded, provided they were no more than 0.02 mg in disagreement. Each silver membrane filter was then loaded into a cassette.

In preparation for each run, each critical orifice or pump was calibrated for flow rate and all sampling trains were placed in the tunnel cross-section with their positions recorded. The cascade impactor, used on alternating runs, was placed on the floor of the large section of the tunnel. The MiniRam, the Squirrel data logger, and their pumps, were prepared with the MiniRam being zeroed both before and after sampling. This was done in order to subtract sensing chamber contamination during the test, thus allowing the dust concentration data to be corrected.

Before sampling, various environmental factors such as temperature, relative humidity, and atmospheric pressure were noted. The exhaust fan and the tunnel fan were turned on together with the MiniRam and its pump and data logger. Sampling was initiated after approximately 15 min when the dust level in the tunnel appeared to have stabilized.

The required masses of silica dust were obtained by assuming an 0.1 mg/h rate of dust accumulation and sequentially closing the valves on the sampling trains at the necessary times. The sampling times ranged from 10 min to 4.5 h.

The test ended with the last sampling train being shut off. The cascade impactor pump and the dust feeder were turned off simultaneously. When the dust concentration was reduced to zero in the tunnel, the exhaust fans, Squirrel data logger and MiniRam were also turned off. The sampling trains were removed from the tunnel and each line was recalibrated to ensure that the air flow rate had remained constant.

After the run, the silver membrane filters were removed from the cassettes and reweighed on the same balance using the same procedure as before. The difference in mass was accepted as the mass of dust on the filters. The cascade impactor filters were left in the weighing room overnight and weighed the following day in the same fashion. The Squirrel data logger information (temperature, humidity, and dust concentration) was downloaded to a computer which produced the data in graphical form. Finally, the equipment was cleaned, recalibrated and prepared for the next sampling session.

Accuracy of the Method

In order to confirm the accuracy of the measured mass on a filter, five filters were each weighed ten times, before and after sampling. Table 1 lists the filter masses before and after sampling, the sample standard deviations, (STD) and the mass of silica on the filters. The uncertainty associated with the silica mass on any given filter is twice the average of the standard deviations listed, or ± 0.016 mg. This figure can be compared to the values in Table 2, which comprises a chart of the results when the same filters were weighed twice only, as was the case with the remaining 95 filters.

Results

The masses of dust on the samples are listed in Table 3. Appendix A contains a series of graphs showing temperature, humidity, and dust concentration for all runs. Appendix B lists the size distribution of dust particles obtained by the cascade impactor during the five days of operation. The conditions, settings and filters of each run are listed in Appendix C, and the positions of the cyclones in the dust tunnel are shown in Appendix D.

Discussion

As anticipated, it was not possible to prepare and supply silica masses strictly between 0.02 and 0.40 mg. Some variability on a day to day basis, as well as variations linked to the dust sampler position in the tunnel cross-section led to heavier than expected silica loads. By pooling the samples collected over all runs and carefully selecting batches to be sent to participants it was possible to prepare proper standard sets.

The variability of 0.016 mg which is the standard deviation calculated over the five selected filters is high compared to the mass of 0.02 mg for the lightest filter. It is, however, as good as twice the Mettler balance's readabiity of 0.01 mg. All filters were weighed at least twice before and twice after sampling.

Conclusions

The methods used here to produce standard silica filters is one of the best means of acquiring a proper airborne respirable silica sample. The methods used and dust tunnel setting are recorded for future use.

Acknowledgement

The authors would like to thank Thomas Pang of the Ontario Ministry of Labour for his role in organizing this work. The authors would also like to thank the Ontario Ministry of Labour, Inco Ltd., Dofasco Inc., and X-Ray Assay Laboratories for their involvement with this project.

References

1. GasTOPS Ltd., "Proposal for the design, manufacture, testing and installation of a dust tunnel", September 1984.

2. Andersen Samplers Inc., "Instruction manual for series 210 ambient cascade impactors".

3. Mie Inc., "MiniRam personal monitor model PDM-3 operations manual", June 1988.

Table 1 - Mass calculated on selected filters using ten weighings

Filter No.	Mass & STD Before Sampling (mg)	Mass & STD After Sampling (mg)	Mass of Silica (mg)
8	123.92 ± 0.0067	124.11 ± 0.0032	0.19
17	113.48 ± 0.0094	113.68 ± 0.0092	0.20
48	113.21 ± 0.0114	113.33 ± 0.0079	0.12
71	105.25 ± 0.0085	105.29 ± 0.0057	0.04
93	111.85 ± 0.0097	111.88 ± 0.0085	0.03

Uncertainty (2 x ave. of STD.) = ± 0.016 mg

Table 2 - Mass calculated on selected filters using two weighings

Filter No.	Mass & STD Before Sampling (mg)	Mass & STD After Sampling (mg)	Mass of Silica (mg)
8	123.92	124.11	0.19
17	113.49	113.68	0.19
48	113.21	113.33	0.12
71	105.26	105.28	0.02
93	111.84	111.88	0.04

Table 3 - Standard filters, associated mass of silica, and length of sampling interval

Filter No.	Time (min)	Mass (mg)	Filter No.	Time (min)	Mass (mg)
1	15	0.02	51	20	0.06
2	30	0.02	52	210	0.04
3	45	0.08	53	120	0.29
4	60	0.12	54	240	0.56
5	120	0.20	55	240	0.54
6	240	0.34	56	120	0.27
7	240	0.32	57	15	0.04
8	120	0.19	58	30	0.06
9	15	0.01	59	20	0.04
10	30	0.03	60	210	0.44
11	45	0.06	61	10	0.02
12	60	0.10	62	15	0.04
13	25	0.06	63	15	0.03
14	40	0.06	64	20	0.05
15	45	0.06	65	20	0.05
16	60	0.10	66	90	0.21
17	120	0.20	67	90	0.02
18	240	0.40	68	90	0.23
19	240	0.41	69	10	0
20	15	0.03	70	15	0.03
21	30	0.06	71	15	0.04
22	15	0.04	72	20	0.05
23	15	0.03	73	15	0.04
24	60	0.10	74	20	0.04

Cont. overleaf

Table 3 - cont.

Filter No.	Time (min)	Mass (mg)	Filter No.	Time (min)	Mass (mg)
25	20	0.03	75	30	0.06
26	38	0.08	76	60	0.13
27	60	0.13	77	90	0.26
28	45	0.08	78	210	0.50
29	120	0.28	79	210	0.50
30	270	0.55	80	90	0.22
31	270	0.53	81	15	0.04
32	120	0.26	82	20	0.04
33	20	0.04	83	30	0.05
34	38	0.04	84	60	0.14
35	60	0.11	85	12	0.04
36	45	0.10	86	12	0.03
37	20	0.05	87	35	0.07
38	35	0.06	88	35	0.08
39	45	0.08	89	90	0.18
40	60	0.12	90	180	0.40
41	120	0.24	91	180	0.39
42	270	0.59	92	90	0.20
43	270	0.55	93	12	0.03
44	120	0.24	94	12	0.02
45	20	0.06	95	35	0.08
46	35	0.07	96	35	0.08
47	45	0.07	97	30	0.07
48	60	0.12	98	30	0.08
49	15	0.02	99	15	0.02
50	30	0.06	100	15	0.03

APPENDIX A

Temperature, Humidity and Dust Concentration Data

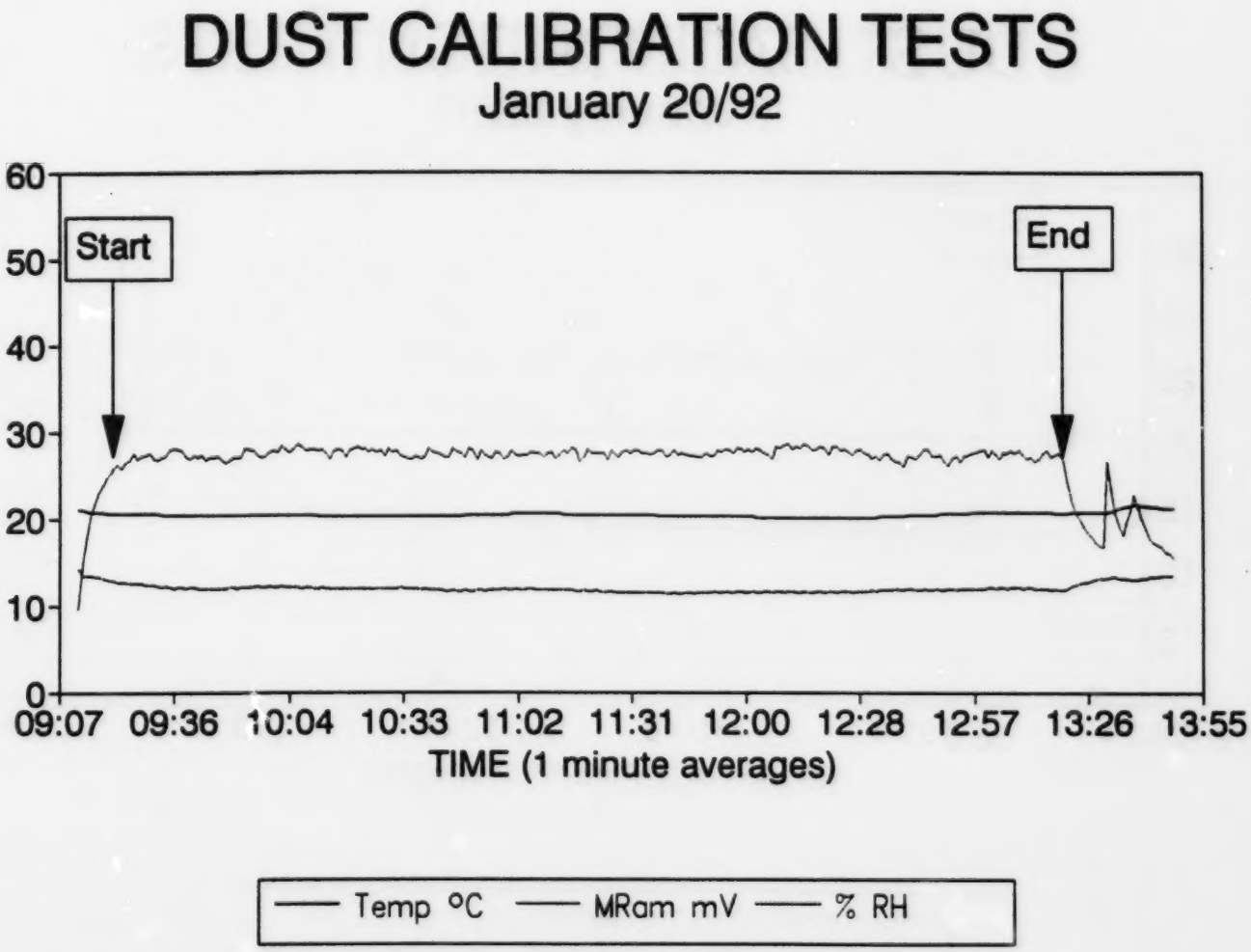


Figure A-1 - Temperature, dust concentration and relative humidity as a function of time for the dust calibration test on 20th January, 1992.

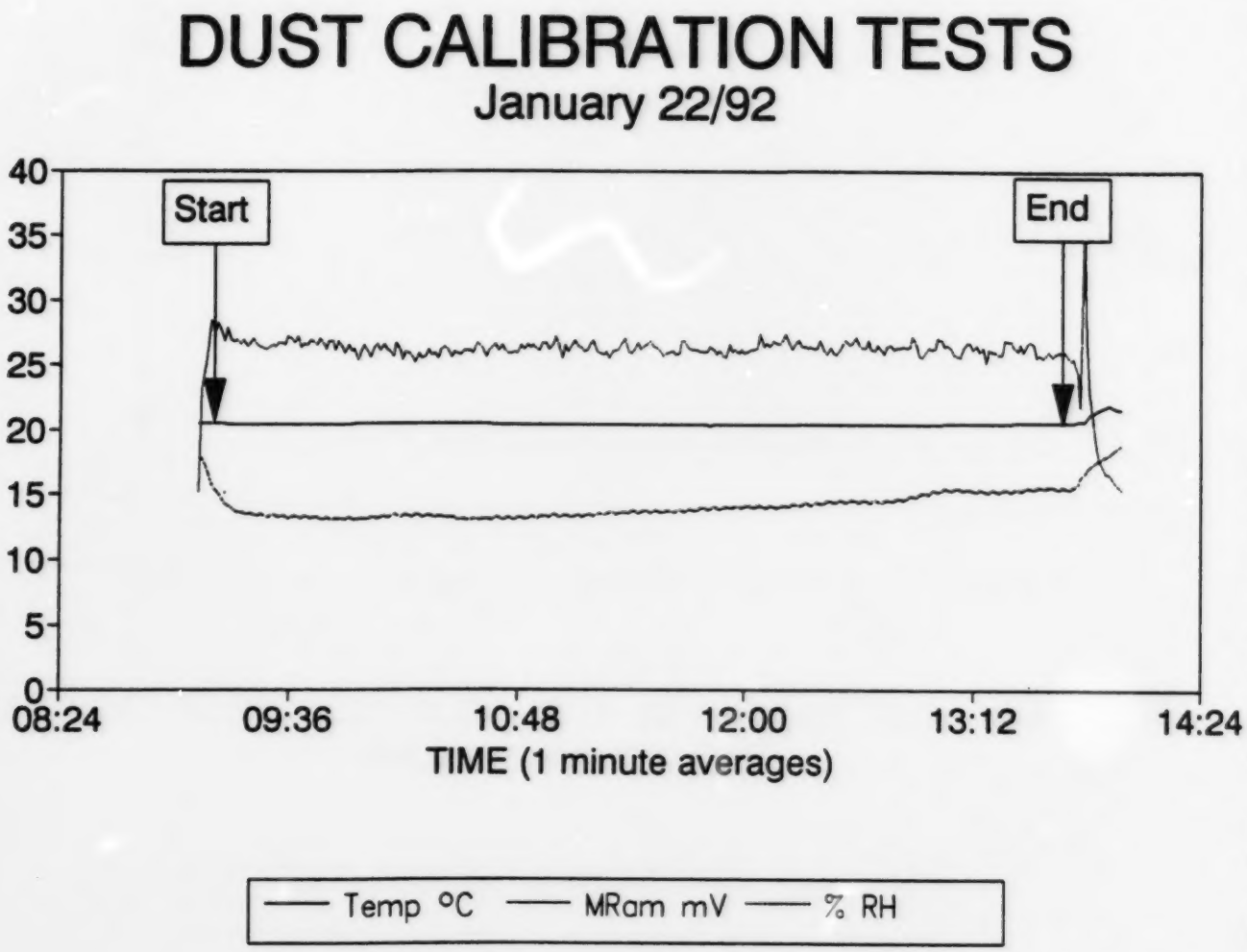


Figure A-2 - Temperature, dust concentration and relative humidity as a function of time for the dust calibration test on 22nd January, 1992.

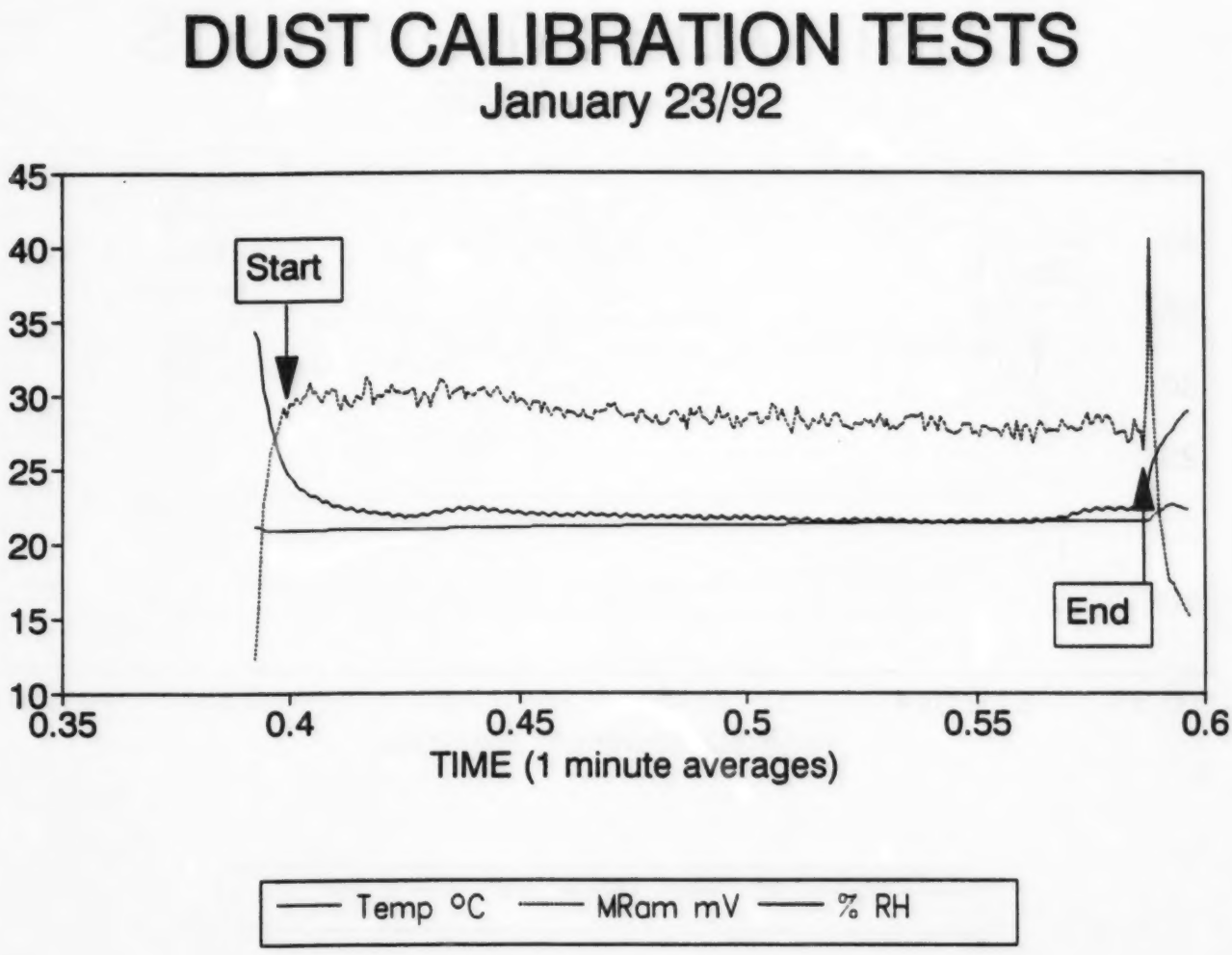


Figure A-3 - Temperature, dust concentration and relative humidity as a function of time for the dust calibration test on 23rd January, 1992.

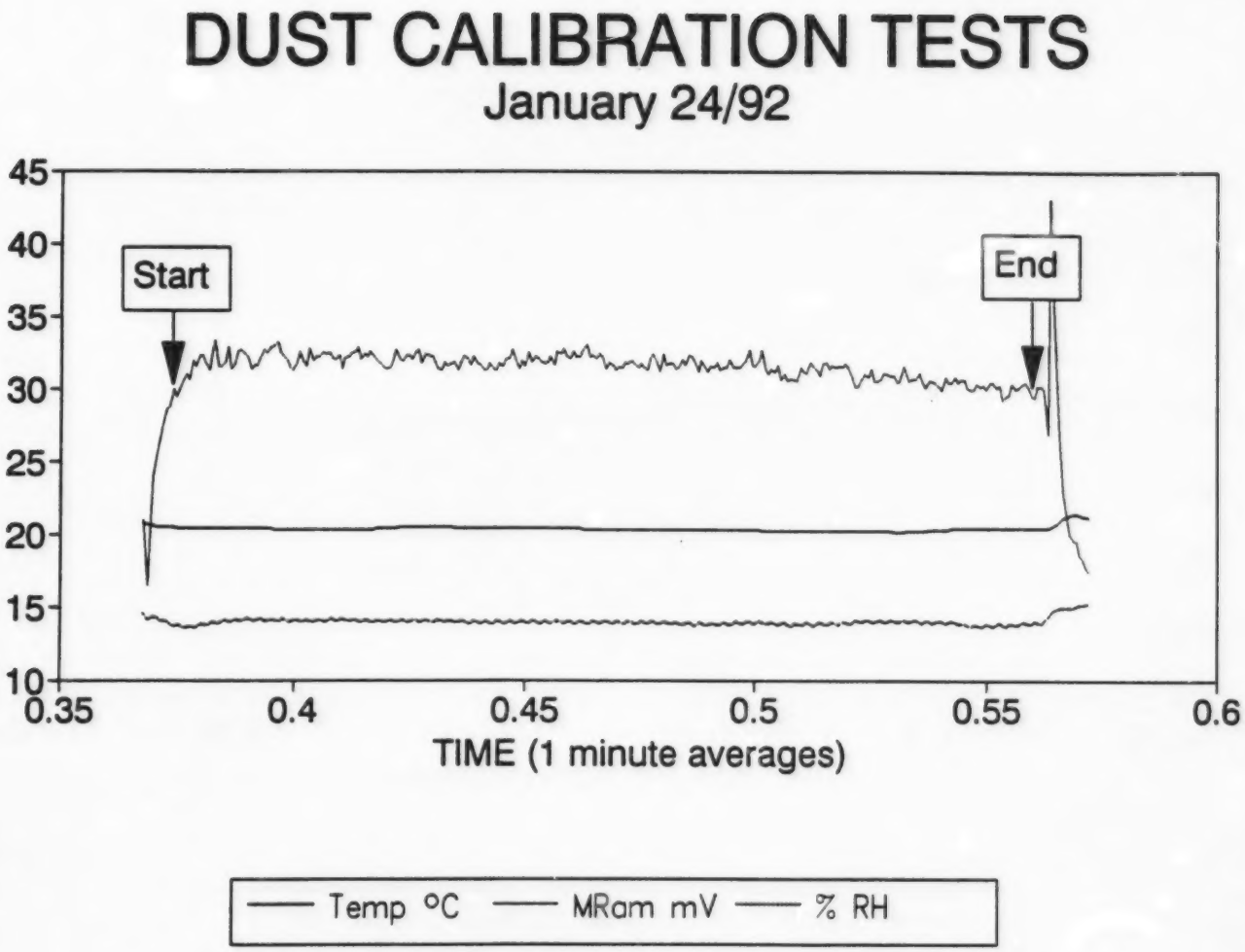


Figure A-4 - Temperature, dust concentration and relative humidity as a function of time for the dust calibration test on 24th January, 1992.

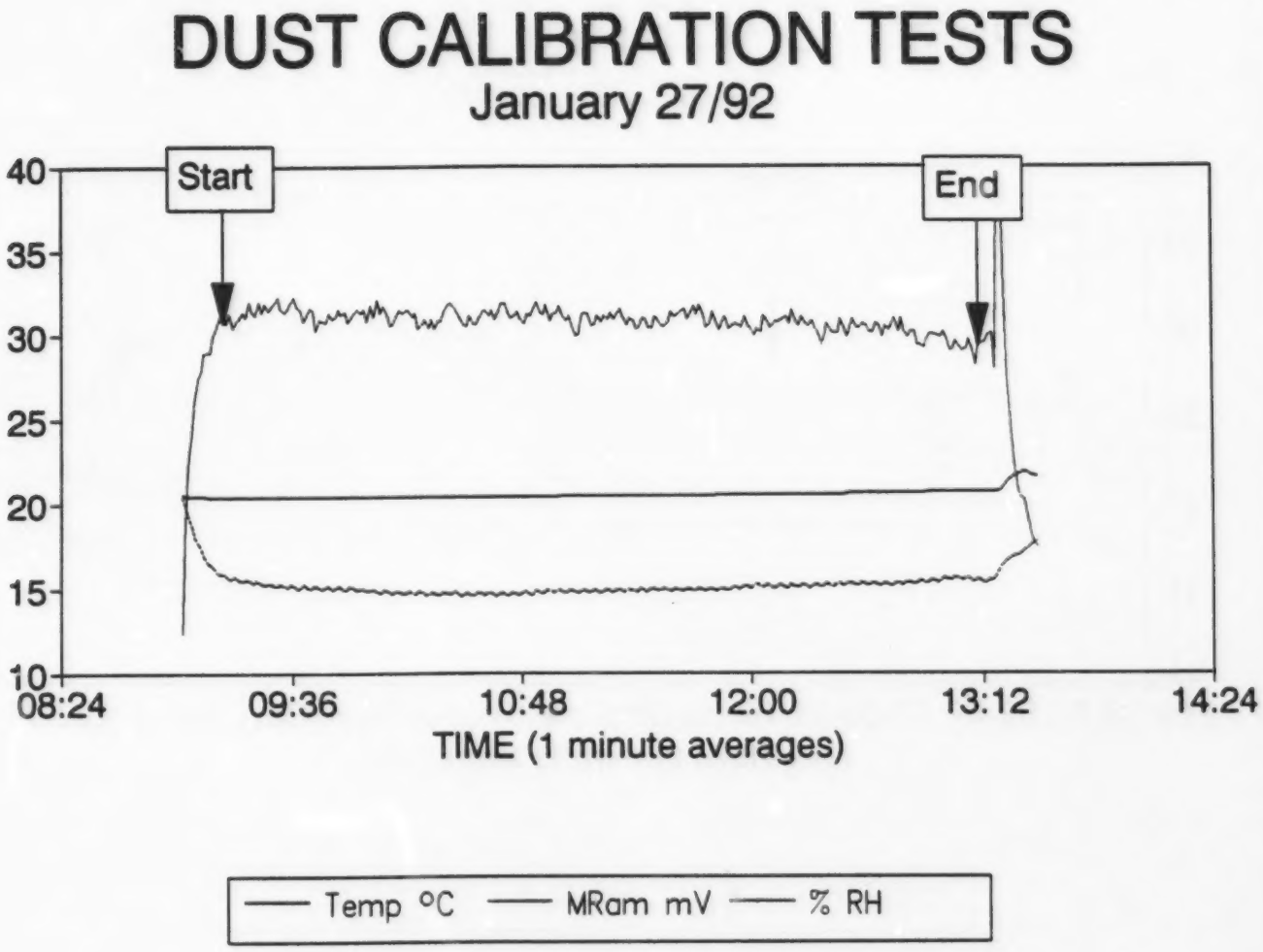


Figure A-5 - Temperature, dust concentration and relative humidity as a function of time for the dust calibration test on 27th January, 1992.

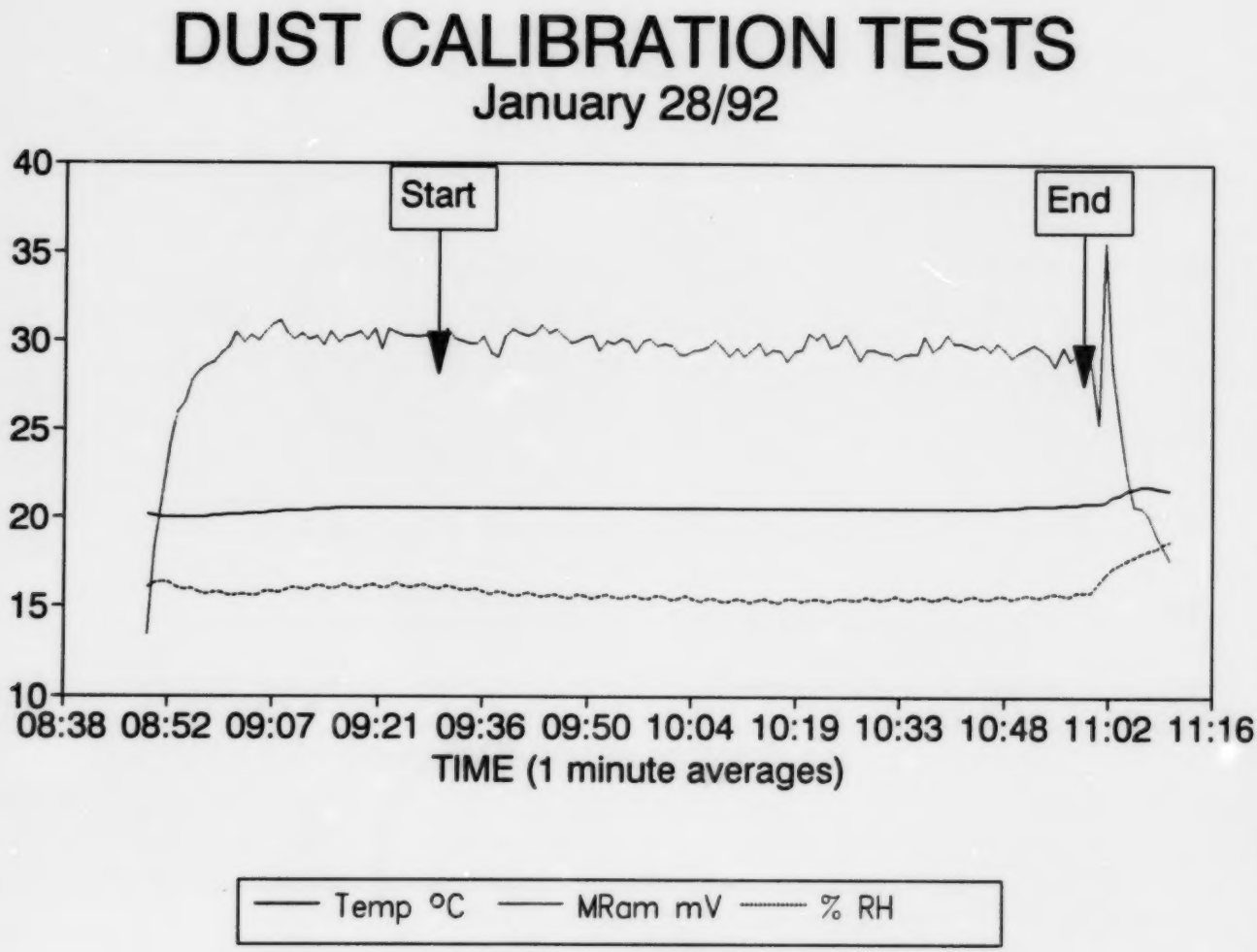


Figure A-6 - Temperature, dust concentration and relative humidity as a function of time for the dust calibration test on 28th January, 1992.

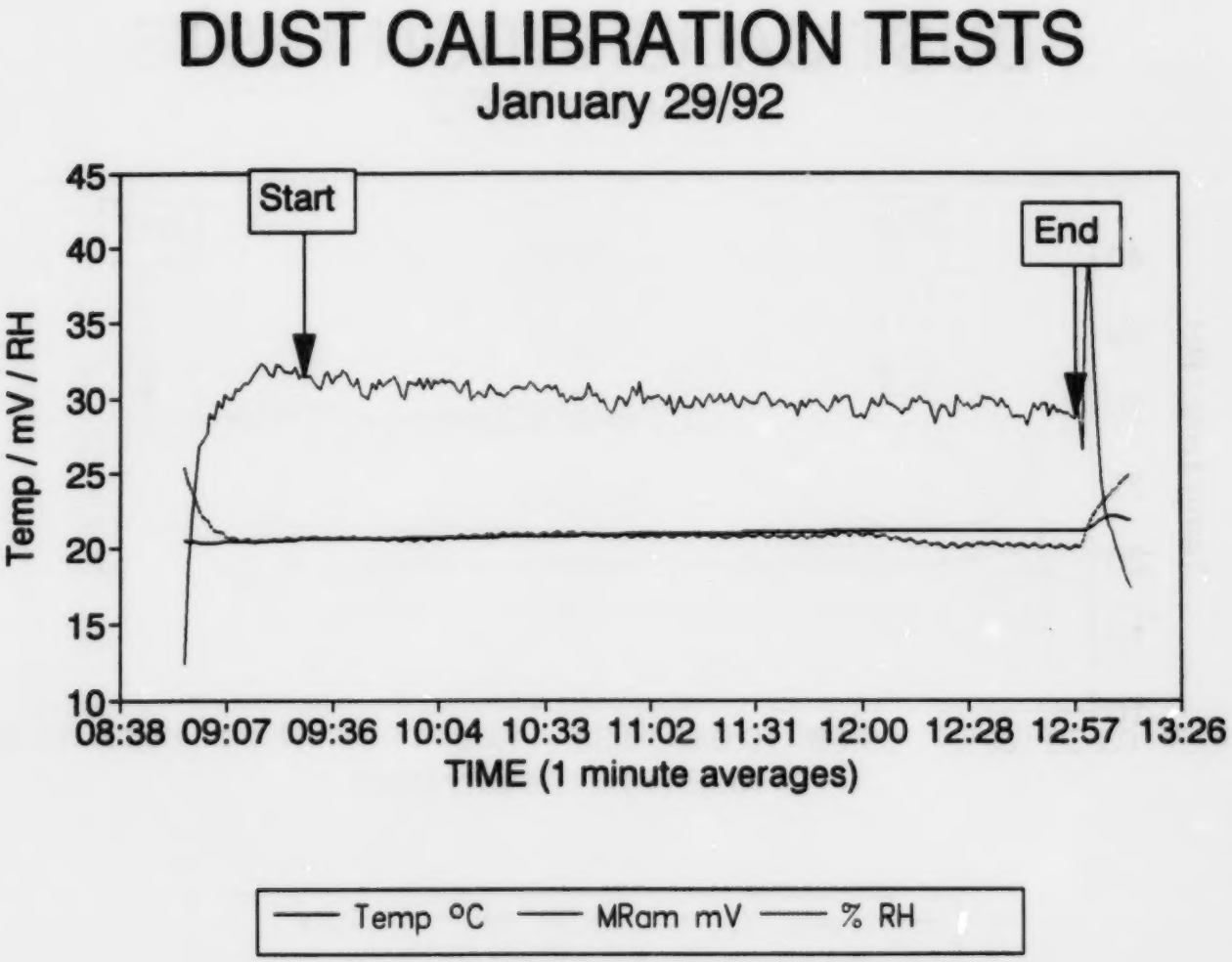


Figure A-7 - Temperature, dust concentration and relative humidity as a function of time for the dust calibration test on 29th January, 1992.

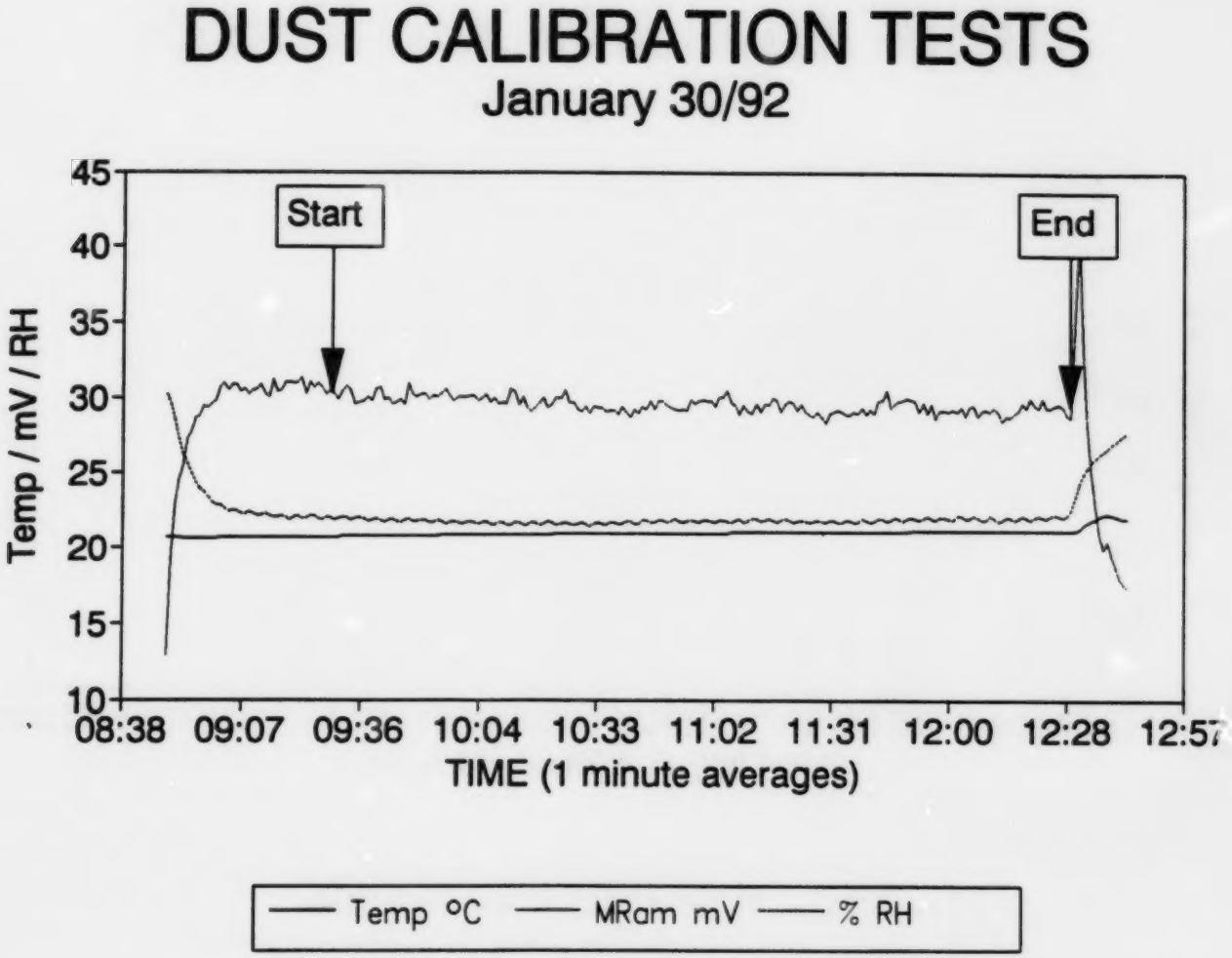


Figure A-8 - Temperature, dust concentration and relative humidity as a function of time for the dust calibration test on 30th January, 1992.

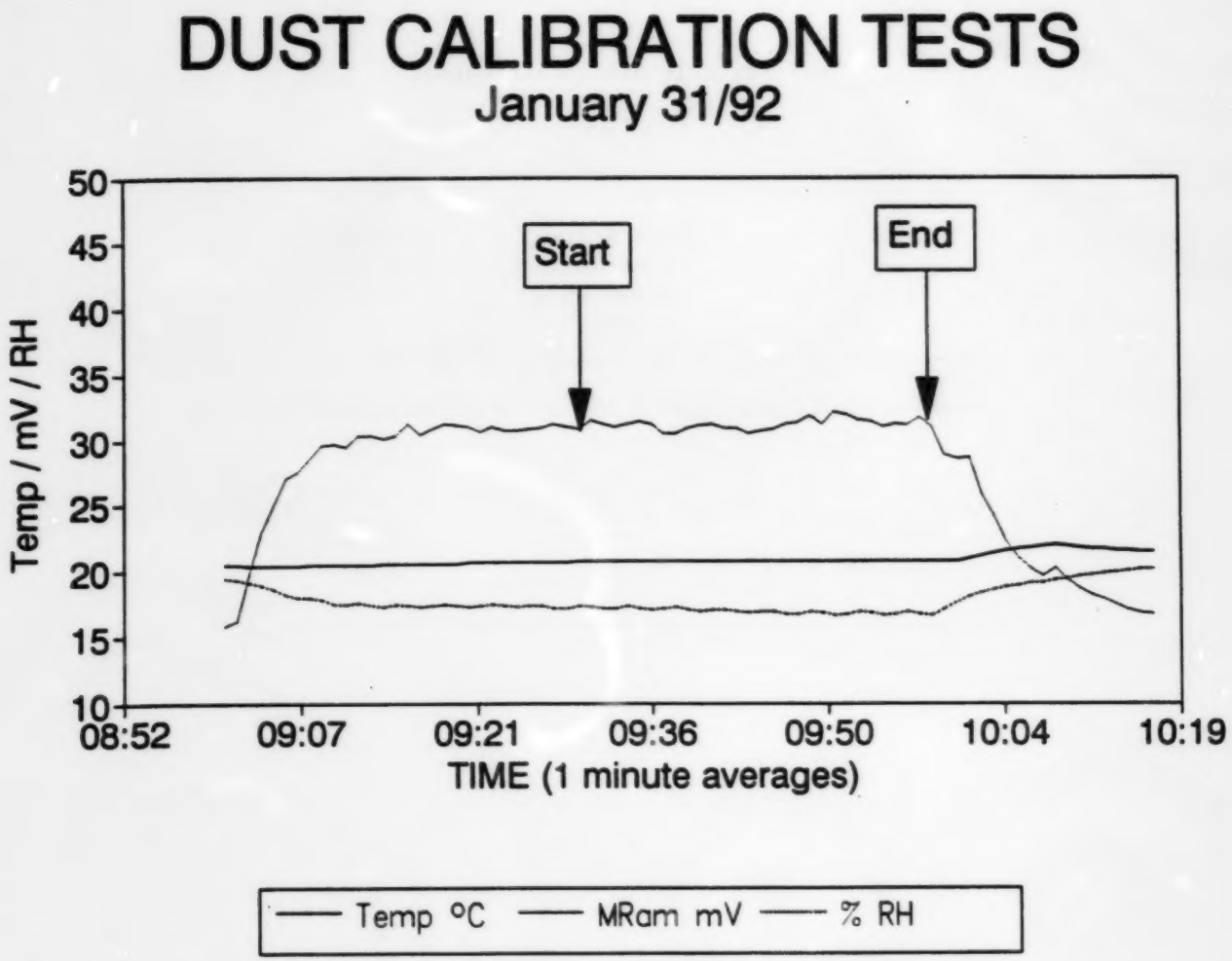


Figure A-9 - Temperature, dust concentration and relative humidity as a function of time for the dust calibration test on 31st January, 1992.

APPENDIX B

Dust Particle Size Distribution

Date	Mass Median Aerodynamic Diameter (μm)	Geometric Std. Dev.
Jan. 20	2.55	2.51
Jan. 23	2.75	2.76
Jan. 27	2.7	2.56
Jan. 29	2.5	2.88
Jan. 31	2.35	3.02

APPENDIX C

Conditions and Settings for Individual Dust Sampling Runs

Jan 20

Miniram Dust Tunnel Calibration

Exhaust Fan Speed (High/Low): Low
Section (S/M/L): L
Manometer Start: 0.324 mbar Manometer Finish: 0.13 mbar
Frequency (Hz): 15.0
Disc Groove (1->small, 5->large): 3

X-Ray Calibration Tests

Tunnel Velocity (m/s): 1.17
Time Start: 9:35 Time Finish: 13:20
Valve Positions: (1) off (2) L (3) on (4) 8
Dust Type: Min-U-Sil 30 micron

Miniram Data

Miniram#: 2 Chamber#: 2 Squirrel#: 2
Flow Through Chamber (Yes/No): yes
Initial Zero: 1.36 (mg) 14.8 (mV)
Final Zero: 2.99 (mg) 37.1 (mV)
Miniram On: 9:13 Miniram Off: 13:50
Position/Configuration: Middle Section / Outside

Cascade Data

Number of Stages: 8 Filter#'s: Day 5 Impactor#: 1
Flow Rate (l/min): 13
Initial Temp: 20.65 °C Final Temp: 20.65 °C
Initial R.H.: 13.3 % Final R.H.: 11.9 %
Initial Bar. Press: 972.6mbar Final Bar. Press: 971.2mbar
Cascade On: 9:20 Cascade Off: 13:20
Position/Configuration: Large chamber, bottom
Comments:

Filter #	Cyclone#	Time Off
1 & 9	T7 & B3	9:35
2 & 10	T5 & B2	9:50
3 & 11	T3 & B1	10:05
4 & 12	T6 & B5	10:20
5 & 8	T4 & B4	11:20
6 & 7	T2 & T1	13:20

refer to Fig. D-1 in appendix D.

Jan 22

Miniram Dust Tunnel Calibration

Exhaust Fan Speed (High/Low): Low
Section (S/M/L): L
Manometer Start: 0.286mbar Manometer Finish: 0.324mbar
Frequency (Hz): 15.0
Disc Groove (1->small, 5->large): 3

X-Ray Calibration Tests

Tunnel Velocity (m/s): 1.02
Time Start: 9:15 Time Finish: 13:45
Valve Positions:(1) off (2) L (3) on (4) 8
Dust Type: Min-U-Sil 30 micron

Miniram Data

Miniram#: 2 Chamber#: 2 Squirrel#: 2
Flow Through Chamber (Yes/No): yes
Initial Zero: 1.38 (mg) 15.0 (Mv)
Final Zero: 2.87 (mg) 35.5 (mV)
Miniram On: 9:09 Miniram Off: 13:58
Position/Configuration: Middle Section / Outside

Cascade Data

Number of Stages: Filter#'s: Impactor#:
Flow Rate (L/min):
Initial Temp: 20.50 °C Final Temp: 20.60 °C
Initial R.H.: 17.7 % Final R.H.: 15.5 %
Initial Bar. Press: 977.0mbar Final Bar. Press:972.6mbar
Cascade On: Cascade Off:
Position/Configuration:
Comments:

Filter #	Cyclone #*	Time Off
13	T7	9:40
14	T5	9:55
15	T3	10:00
16 & 24	T6 & B1	10:15
17	T4	11:15
18 & 19	T2 & T1	13:45

* refer to Fig. D-2 in Appendix D

Jan 23

Miniram Dust Tunnel Calibration

Exhaust Fan Speed (High/Low): Low
Section (S/M/L): L
Manometer Start: 0.324mbar Manometer Finish: 0.324mbar
Frequency (Hz): 15.0
Disc Groove (1->small, 5->large): 3

X-Ray Calibration Tests

Tunnel Velocity (m/s): 0.98
Time Start: 9:35 Time Finish: 14:05
Valve Positions:(1) off (2) L (3) on (4) 8
Dust Type: Min-U-Sil 30 micron

Miniram Data

Miniram#: 2 Chamber#: 2 Squirrel#: 2
Flow Through Chamber (Yes/No): yes
Initial Zero: 1.38 (mg) 14.8 (mV)
Final Zero: 2.84 (mg) 35.2 (mV)
Miniram On: 9:26 Miniram Off: 14:19
Position/Configuration: Middle Section / Outside

Cascade Data

Number of Stages: 8 Filter#'s: Day 6 Impactor#: 1
Flow Rate (L/min): 13.0
Initial Temp: 21.15 °C Final Temp: 21.55 °C
Initial R.H.: 34.4 % Final R.H.: 22.5 %
Initial Bar. Press: 949.5mbar Final Bar. Press: 944.5mbar
Cascade On: 9:35 Cascade Off: 14:05
Position/Configuration: Large chamber, bottom
Comments: When calibrated, the MINIRAM pump drew 2320 cc/min using the same set-up as for the vacuum pump.

Filter #	Cyclone #*	Time Off
25 & 33	T7 & B4	9:55
26 & 34	T5 & B3	10:13
27 & 35	T3 & B2	10:35
28 & 36	T6 & B1	10:20
29 & 32	T4 & B5	11:35
30 & 31	T2 & T1	14:05

* refer to Fig D-2 in Appendix D

Jan 24

Miniram Dust Tunnel Calibration

Exhaust Fan Speed (High/Low): Low
Section (S/M/L): L
Manometer Start: 0.324mbar Manometer Finish: 0.324mbar
Frequency (Hz): 15.0
Disc Groove (1->small, 5->large): 3

X-Ray Calibration Tests

Tunnel Velocity (m/s): 0.70
Time Start: 9:00 Time Finish: 13:30
Valve Positions:(1) off (2) L (3) on (4) 8
Dust Type: Min-U-Sil 30 micron

Miniram Data

Miniram#: 2 Chamber#: 2 Squirrel#: 2
Flow Through Chamber (Yes/No): yes
Initial Zero: 1.48 (mg) 16.1 (mV)
Final Zero: 2.86 (mg) 35.0 (mV)
Miniram On: 9:50 Miniram Off: 13:44
Position/Configuration: Middle Section / Outside

Cascade Data

Number of Stages: Filter#'s: Impactor#:
Flow Rate (L/min):
Initial Temp: 20.60 °C Final Temp: 20.40 °C
Initial R.H.: 14.2 % Final R.H.: 20.4 %
Initial Bar. Press: 958.3mbar Final Bar. Press: 963.4mbar
Cascade On: Cascade Off:
Position/Configuration:
Comments: Vacuum pump off from overheat at 10:54, back on at 11:01

Filter #	Cyclone #*	Time Off
37 & 45	T7 & B4	9:20
38 & 46	T5 & B3	9:35
39 & 47	T3 & B2	9:45
40 & 48	T6 & B1	10:00
41 & 44	T4 & B5	11:00
42 & 43	T2 & T1	13:30

* refer to Fig D-2 in Appendix D

Jan 27

Miniram Dust Tunnel Calibration

Exhaust Fan Speed (High/Low): Low
Section (S/M/L): L
Manometer Start: 0.326mbar Manometer Finish: 0.324mbar
Frequency (Hz): 15.0
Disc Groove (1->small, 5->large): 3

X-Ray Calibration Tests

Tunnel Velocity (m/s): 0.73
Time Start: 9:15 Time Finish: 13:15
Valve Positions:(1) off (2) L (3) on (4) 8
Dust Type: Min-U-Sil 30 micron

Miniram Data

Miniram#: 2 Chamber#: 2 Squirrel#: 2
Flow Through Chamber (Yes/No): yes
Initial Zero: 1.40 (mg) 15.1 (mV)
Final Zero: 2.46 (mg) 29.6 (mV)
Miniram On: 9:02 Miniram Off: 13:29
Position/Configuration: Middle Section / Outside

Cascade Data

Number of Stages: 8 Filter#'s: Day 7 Impactor#: 1
Flow Rate (L/min): 13.0
Initial Temp: 20.45 °C Final Temp: 21.45 °C
Initial R.H.: 19.2 % Final R.H.: 18.0 %
Initial Bar. Press.: 979.0mbar Final Bar. Press.:
Cascade On: 9:15 Cascade Off: 13:15
Position/Configuration: Large chamber, bottom
Comments:

Filter #	Cyclone #*	Time Off
49 & 57	T7 & B4	9:30
50 & 58	T5 & B3	9:45
51 & 59	T3 & B2	9:35
52 & 60	T1 & B1	12:45
53 & 56	T4 & B5	11:15
54 & 55	T2 & T1	13:15

* refer to Fig. D-2 in Appendix D

Jan 28

Miniram Dust Tunnel Calibration

Exhaust Fan Speed (High/Low): Low
Section (S/M/L): L
Manometer Start: 0.324mbar* Manometer Finish: 0.324mbar
Frequency (Hz): 15.0
Disc Groove (1->small, 5->large): 3

X-Ray Calibration Tests

Tunnel Velocity (m/s): 0.71
Time Start: 9:00 Time Finish: 11:00
Valve Positions: (1) off (2) L (3) on (4) 8
Dust Type: Min-U-Sil 30 micron

Miniram Data

Miniram#: 2 Chamber#: 2 Squirrel#: 2
Flow Through Chamber (Yes/No): yes
Initial Zero: 1.39 (mg) 15.1 (mV)
Final Zero: 1.80 (mg) 20.9 (mV)
Miniram On: 8:50 Miniram Off: 11:12
Position/Configuration: Middle Section / Outside

Cascade Data

Number of Stages: Filter#'s: Impactor#:
Flow Rate (L/min):
Initial Temp: 20.15 °C Final Temp: 20.80 °C
Initial R.H.: 15.2 % Final R.H.: 15.8 %
Initial Bar. Press: 984.1mbar Final Bar. Press: 984.1mbar
Cascade On: Cascade Off:
Position/Configuration:
Comments:

Filter #	Cyclone #*	Time Off
61 & 69	T7 & B4	9:40
62, 62, 70, & 71	T5, T3, B3, & B2	9:45
64, 65, & 72	T6, T4, & B1	9:50
66, 67, & 68	T2, T1, & B5	11:00

* refer to Fig. D-2 in Appendix D

Jan 29

Miniram Dust Tunnel Calibration

Exhaust Fan Speed (High/Low): Low
Section (S/M/L): L
Manometer Start: 0.324mbar Manometer Finish: 0.324mbar
Frequency (Hz): 15.0
Disc Groove (1->small, 5->large): 3

X-Ray Calibration Tests

Tunnel Velocity (m/s): 0.70
Time Start: 9:30 Time Finish: 13:00
Valve Positions:(1) off (2) L (3) on (4) 8
Dust Type: Min-U-Sil 30 micron

Miniram Data

Miniram#: 2 Chamber#: 2 Squirrel#: 2
Flow Through Chamber (Yes/No): yes
Initial Zero: 1.40 (mg) 15.1 (mV)
Final Zero: 2.47 (mg) 29.7 (mV)
Miniram On: 8:57 Miniram Off: 13:14
Position/Configuration: Middle Section / Outside

Cascade Data

Number of Stages: 8 Filter#'s: Day 8 Impactor#: 1
Flow Rate (L/min): 13.0
Initial Temp: 20.45 °C Final Temp: 21.20 °C
Initial R.H.: 23.7 % Final R.H.: 20.3 %
Initial Bar. Press: 976.0mbar Final Bar. Press: 971.9mbar
Cascade On: 9:47 Cascade Off: 13:00
Position/Configuration: Large chamber, bottom
Comments:

Filter #	Cyclone #*	Time Off
73 & 81	T7 & B4	9:45
74 & 82	T5 & B3	9:50
75 & 83	T3 & B2	10:00
76 & 84	T6 & B1	10:30
77	T4	11:00
78 & 79	T2 & T1	13:00

80 (B5) left on from calibration, off at 9:21

* refer to Fig. D-2 in Appendix D

Jan 30

Miniram Dust Tunnel Calibration

Exhaust Fan Speed (High/Low): Low
Section (S/M/L): L
Manometer Start: 0.324mbar Manometer Finish: 0.324mbar
Frequency (Hz): 15.0
Disc Groove (1->small, 5->large): 3

X-Ray Calibration Tests

Tunnel Velocity (m/s): 0.69
Time Start: 9:30 Time Finish: 12:30
Valve Positions:(1) off (2) L (3) on (4) 8
Dust Type: Min-U-Sil 30 micron

Miniram Data

Miniram#: 2 Chamber#: 2 Squirrel#: 2
Flow Through Chamber (Yes/No): yes
Initial Zero: 1.40 (mg) 15.2 (mV)
Final Zero: 2.57 (mg) 31.2 (mV)
Miniram On: 9:50 Miniram Off: 12:45
Position/Configuration: Middle Section / Outside

Cascade Data

Number of Stages: Filter#'s: Impactor#:
Flow Rate (L/min):
Initial Temp: 20.75 °C Final Temp: 21.20 °C
Initial R.H.: 29.9 % Final R.H.: 22.4 %
Initial Bar. Press: 963.4mbar Final Bar. Press: 962.8mbar
Cascade On: Cascade Off:
Position/Configuration:
Comments: #94 facing to the side at 10:00, pump off from overheat at 11:00, on at 11:04

Filter #	Cyclone #*	Time Off
85, 86, 93, & 94	T7, T5, B4, & B3	9:42
87, 88, 95, & 96	T3, T6, B2, & B1	10:05
89 & 92	T4 & B5	10:45
90 & 91	T2 & T1	12:30

* refer to Fig. D-2 in Appendix D

Jan 31

Miniram Dust Tunnel Calibration

Exhaust Fan Speed (High/Low): Low
Section (S/M/L): L
Manometer Start: 0.327mbar Manometer Finish: 0.327mbar
Frequency (Hz): 15.0
Disc Groove (1->small, 5->large): 3

X-Ray Calibration Tests

Tunnel Velocity (m/s): 0.71
Time Start: 9:30 Time Finish: 10:00
Valve Positions:(1) off (2) L (3) on (4) 8
Dust Type: Min-U-Sil 30 micron

Miniram Data

Miniram#: 2 Chamber#: 2 Squirrel#: 2
Flow Through Chamber (Yes/No): yes
Initial Zero: 1.43 (mg) 15.7 (mV)
Final Zero: 1.74 (mg) 19.9 (mV)
Miniram On: 8:02 Miniram Off: 10:18
Position/Configuration: Middle Section / Outside

Cascade Data

Number of Stages: 8 Filter#'s: Day 9 Impactor#: 1
Flow Rate (L/min): 12.8
Initial Temp: 20.40 °C Final Temp: 20.70 °C
Initial R.H.: 19.1 % Final R.H.: 16.9 %
Initial Bar. Press: 968.5mbar Final Bar. Press: 968.8mbar
Cascade On: 9:30 Cascade Off: 10:00
Position/Configuration: Large chamber, bottom
Comments:

Filter #	Cyclone #	Time Off
20, 22, 23, 99, & 100	T7, T5, T4, T1, & B1	9:45
21, 97, & 98	T6, T3, & T2	10:00

APPENDIX D

Cyclone Sampler Positions

Fig D-1: Cyclone Positions for Jan 20

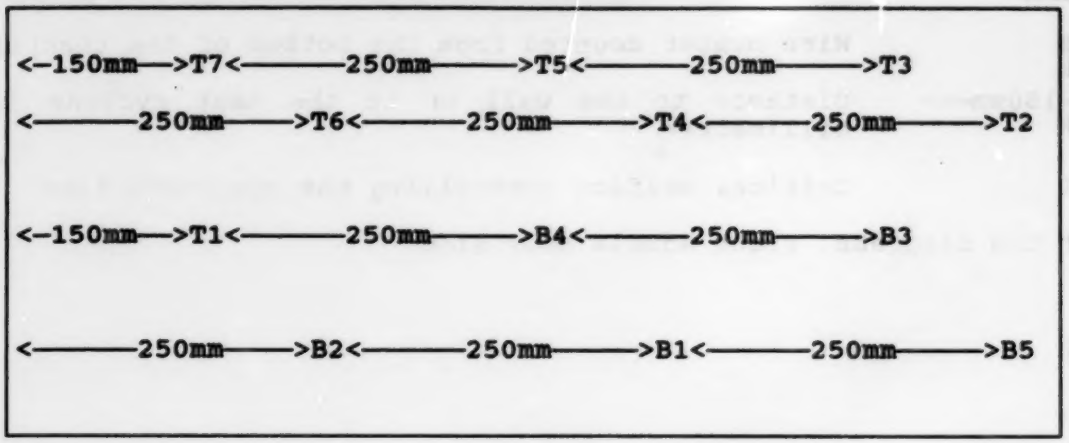


Fig D-2: Cyclone Positions for Jan 22 to Jan 30

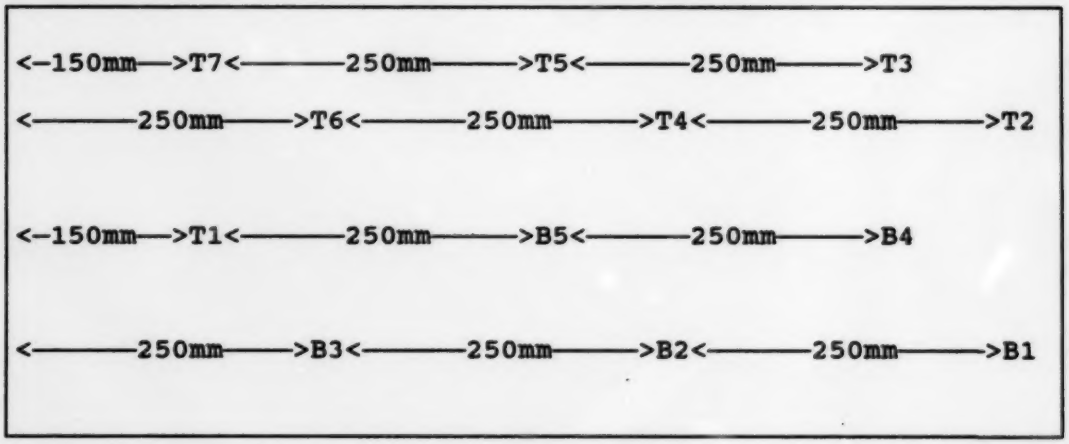
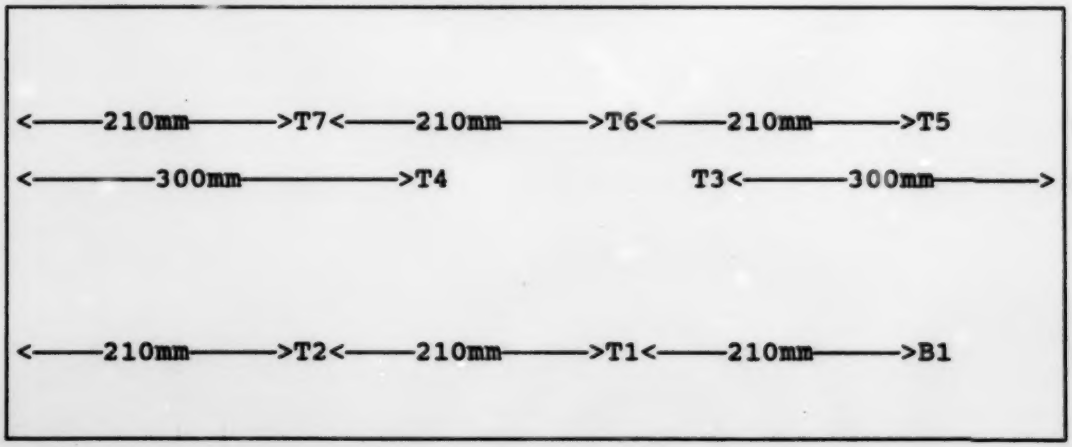


Fig D-3: Cyclone Positions for Jan 31



Legend

#8	Wire number counted from the bottom of the chamber
<-150mm-->	Distance to the wall or to the next cyclone in millimetres
T1	Critical orifice controlling the cyclone's flow

For the diagrams, right equals door side.